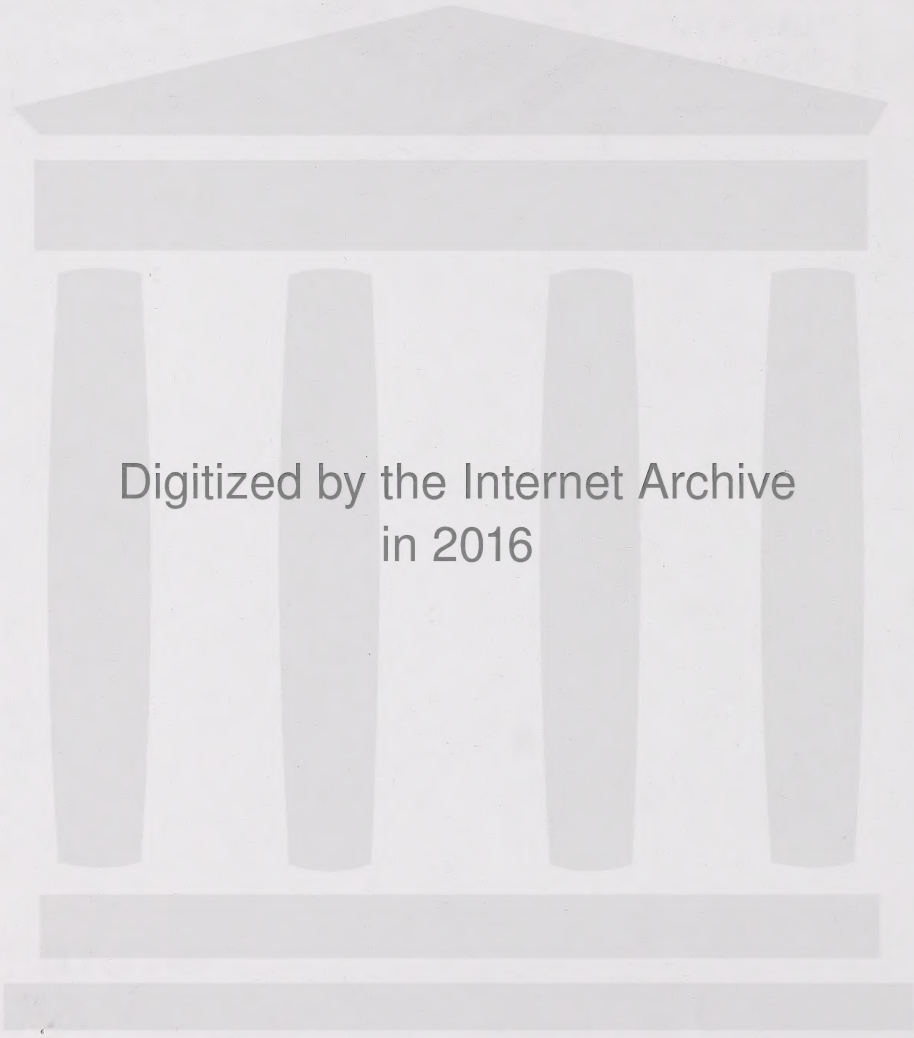
PESTICIDE EDUCATION PROGRAM

Vegetative Management Study

STUDENT MATERIALS

Printed on Recycled Paper



STUDENT WORKSHEET - PLANTS AND ECOSYSTEMS

1. What uses are there for plants? What do plants provide?

2. What factors determine where plants grow?

3. Name some major classifications of plants.

4. Describe an ecosystem for the following plant communities:
   a) Mixed wood (spruce and poplar) -

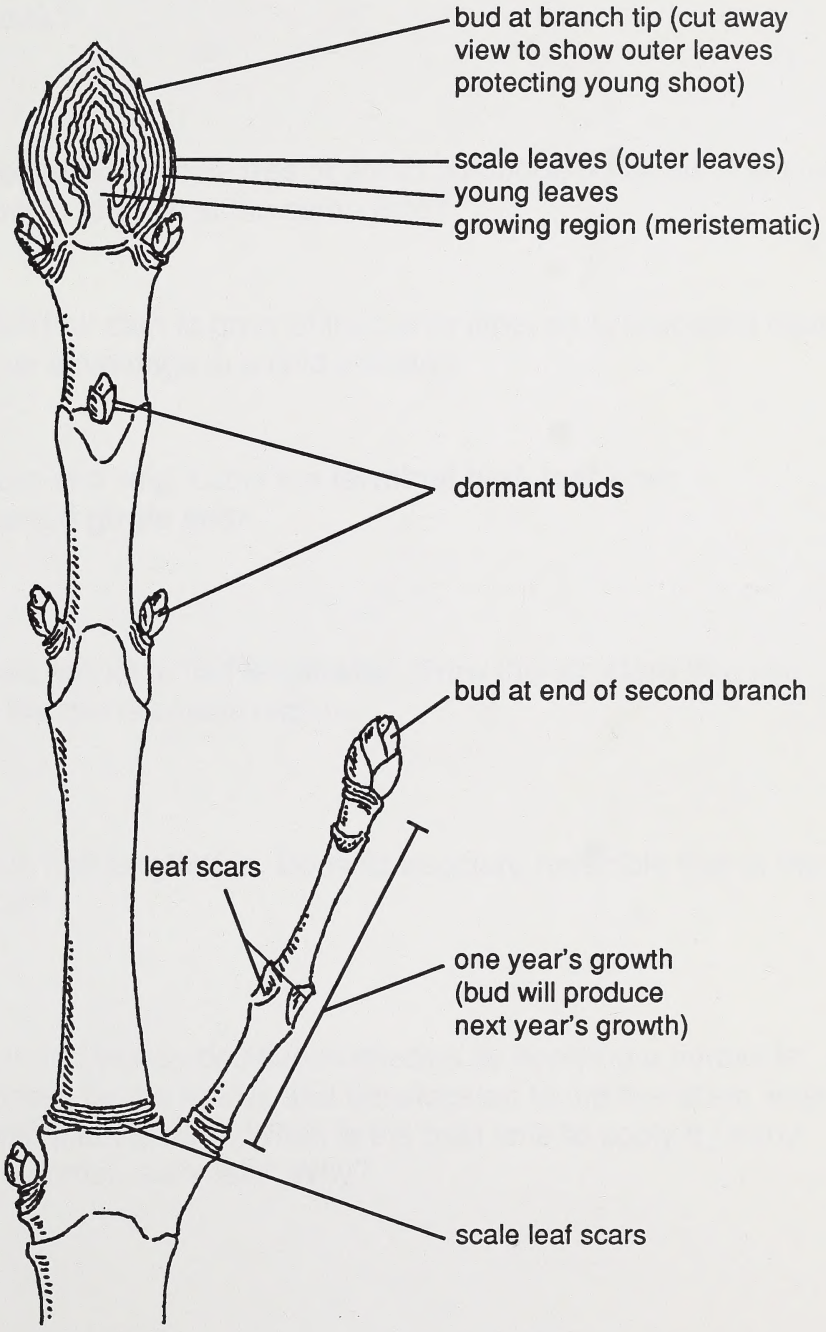
   b) Natural grassland -

5. A field of wheat is also a grass ecosystem. What are some differences between it and a natural prairie?

6. What is a forest?

7. Name as many factors as you can which define the ecosystem of a particular location.

BRANCH DIAGRAM



STUDENT WORKSHEET - PLANT GROWTH

1. Do all species begin to grow at the same time or is there a variation between species?

2. If you have observed a whole tree or shrub outdoors, do all the branches on the plant begin to grow at the same time?

3. If branches don't all start to grow at the same time, does that plant have any competitive advantage in a cold climate?

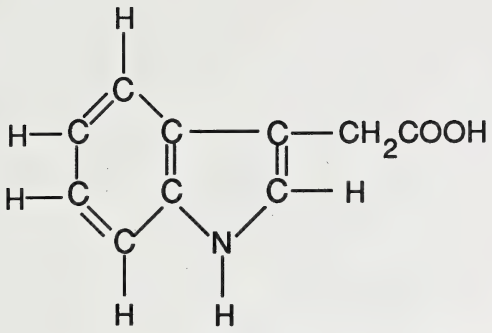
4. Draw a diagram of a twig. Label the **terminal bud**, **leaf scar**, **lateral bud**, and a **girdle scar**.

5. Slice a brussels sprout in half lengthwise. Draw the structure that you see. Indicate the meristematic region.

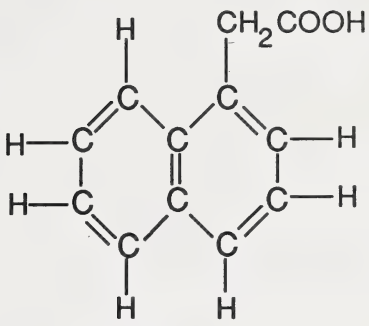
6. Cut a twig tip in half lengthwise. Does its structure resemble that of the brussels sprout?

7. You wish to control woody deciduous species by applying a herbicide which is absorbed by the leaves and translocated to the meristem where it interferes with plant growth. When is the best time to apply it - early spring, early summer, early fall? Why?

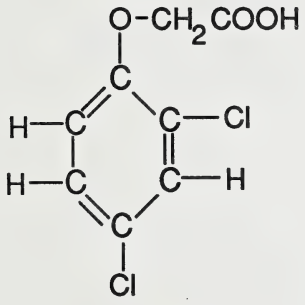
AUXIN PLANT REGULATORS



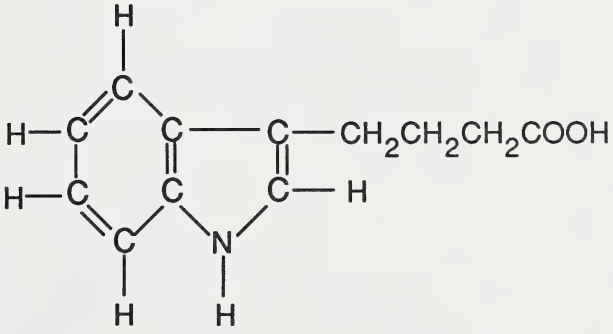
1AA
3-Indoleacetic acid



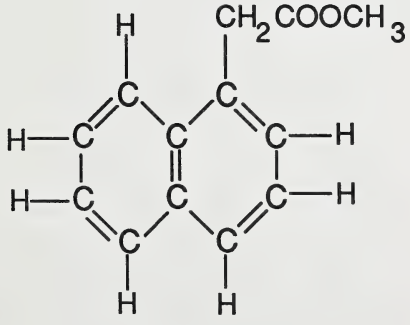
NAA
α-Naphthaleneacetic acid



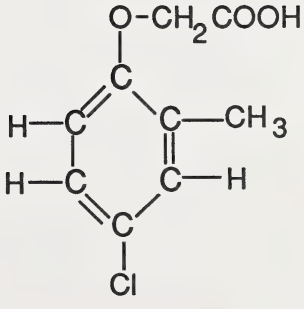
2,4 - D
2,4-Dichlorophenoxyacetic acid



IBA
3-Indolebutyric acid

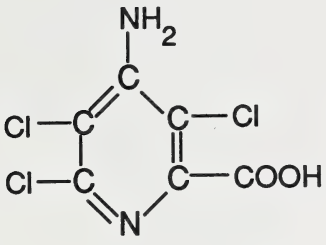


MENA
Methylester of α–naphthalene-acetic acid

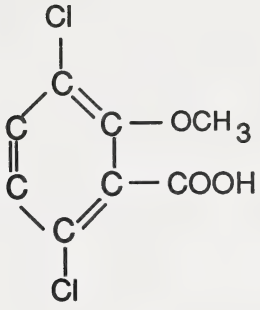


MCPA
2-methyl-4-chlorophenoxy-acetic acid

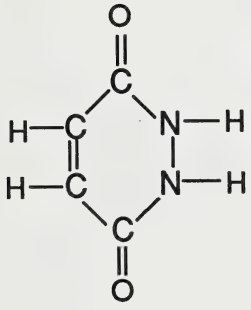
NON - AUXIN GROWTH REGULATORS



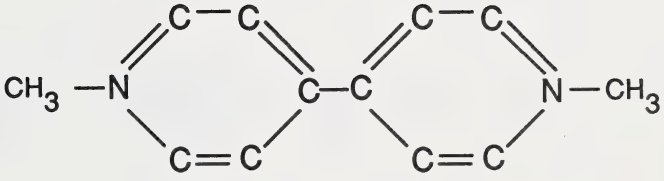
PICLORAM
2-carboxy-4-amino-3,5,6-trichloro pyridine



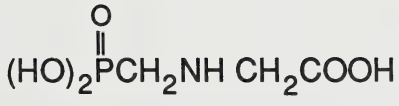
DICAMBA
2-methoxy-3,6-dichloro benzoic acid



MH
maleic hydrazide



PARAQUAT



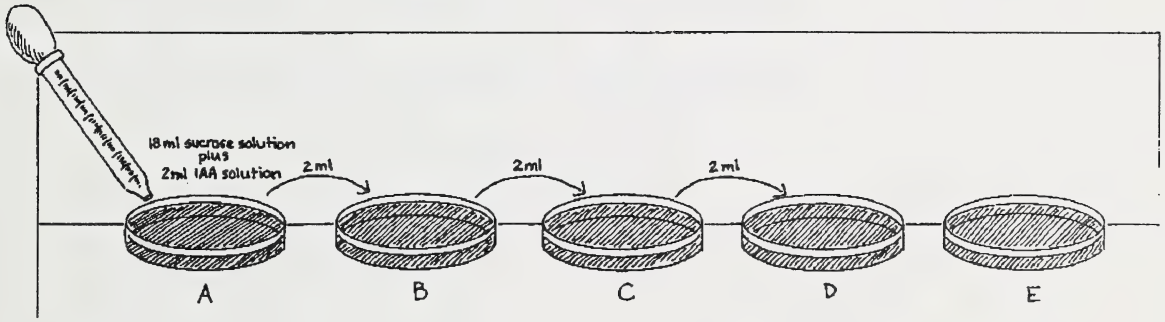
Glyphosphate

STUDENT LAB SHEET - CELL ELONGATION CAUSED BY AUXIN ACTIVITY

In this experiment, you will be able to observe the effects of auxin activity on sections cut from oat seedlings.

You will use: 5 petri dishes
50 oat seedlings
cutting device
measuring device (graduate cylinder or pipette)
2% sucrose solution
IAA solution (100 mg/ml)

Your teacher may also ask you to test an IAA solution (concentration unknown to you) in 2% sucrose. If so, you will need an extra petri dish and 10 more seedlings.



Method:

1) Label 5 dishes A-E. Into each place 18 ml of the sucrose solution. Into A, place 2 ml of the IAA solution (100 mg/l). Mix thoroughly, then withdraw 2 ml and add it to B. Mix B thoroughly, withdraw 2 ml and add to C. Repeat from C to D. Do not add any IAA to E.

If you are testing an unknown, add 18 ml of the unknown to plate F.

Dilutions: A - 10 mg/l E - 0 mg/l
B - 1 mg/l F - x mg/l
C - 0.1 mg/l
D - 0.01 mg/l

2) Cut 10 mm sections from oat seedlings (cut 2-3 mm back from the tip, one section only per seedling - see diagram).
3) Quickly place 10 sections in each dish, cover and place in a dark location for 48 hours.

Results: Measure each section and record the length. Determine in mm the average change in length for each treatment.

CONCENTRATION (mg/l)	0	.01	.1	1	10
AVERAGE CHANGE (mm)					

If you have done an unknown, plot a logarithmic graph of concentration vs. growth (change in length). Use the change in length of those in the unknown solution to determine its concentration from the graph.

What is the purpose of the sucrose in this experiment?

Conclusions: What effect does IAA have on cell growth?

STUDENT WORKSHEET - POWERLINE RIGHTS-OF-WAY (ROW) CASE STUDY

Groups 1, 2, 3 - You represent citizens concerned about a proposed power transmission line. You must work together to write a letter to the power company outlining your concerns.

Group 1: You represent The Wildlife Protection Association and are concerned that construction of the line will destroy habitat for forest animals since it passes through a mixed-wood (Poplar and white spruce) area. You want to know what the environmental impact of this project will be. What specific concerns do you have?

Letter 2: A substation is to be constructed in an agricultural area. As farmers, you are concerned either that noxious weeds will spread from the site onto nearby fields or that herbicide might leach off the site and possibly affect your canola crops. The soil is very fertile, with a good organic content. Outline your concerns and questions in your letter to the company.

Letter 3: The line is to pass between a poplar stand and a school. As parents, you are worried about herbicide use near the schoolyard. You are afraid that children might come in contact with drift during spraying or with residual herbicide if they play on the right-of way after spraying. Raise any other concerns you can think of in your letter to the company.

Groups 4, 5, 6 - As members of the environmental affairs department for a power company, you have received letters from a number of people regarding a proposed transmission line. These letters are outlined below. How would you respond to these concerns? Let the writers know how the right-of-way will be managed to avoid the problems they foresee. Herbicides will probably play a part in the management program, so discuss choice of herbicide as well as application methods and timing. Are other alternatives available for consideration? If you can think of other options, discuss them as well.

Response to Letter 1: Discuss the environmental effects of maintenance in the area. How will the program be designed to avoid water contamination? Discuss any other concerns the letter raises.

Response to Letter 2: Suggest a suitable control program . What herbicides would you use? Why? Discuss any other concerns the letter raises.

Response to Letter 3: What chemicals might be used and how? What would minimize chances of accidental contamination? Are there alternatives? Discuss any other concerns the letter raises.

PLANTS ARE WILDLIFE TOO!

Most people think of wildlife exclusively in terms of animals - deer, moose, bears or beaver, but what about the lady's slipper, cattail or black spruce? They too grow and live in the wild. Not only that, but the type of plant life which grows in an area determines the type of animal life which can survive there. The interrelationships between plants and animals, microorganisms, and non-living factors such as soils and climate define the ecosystem of an area.

NATURAL ECOSYSTEMS IN ALBERTA

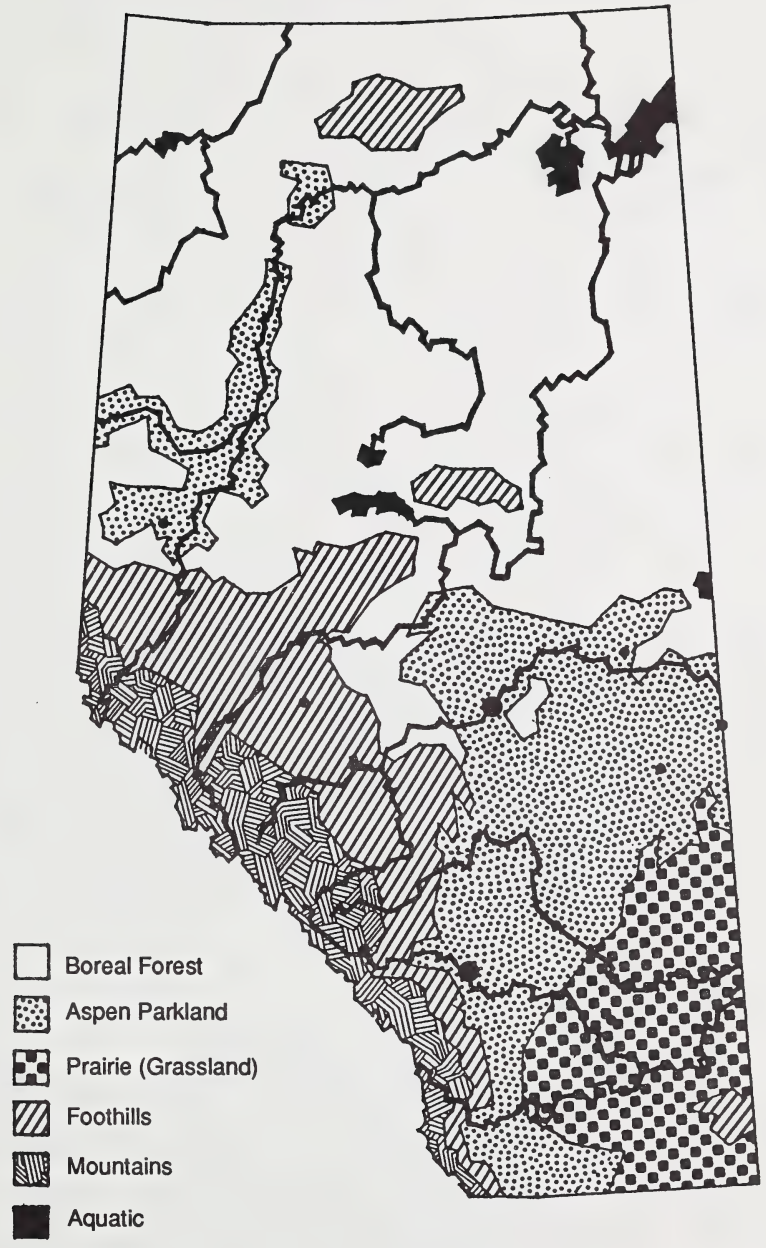
In Alberta, there are five major natural ecosystem types - prairie, aspen parkland, boreal forest, mountain and aquatic. There are subdivisions within each type. For example variations in moisture levels cause differences in vegetation along a water course or around a body of water.

Prairie - On the native prairie lands which once covered a large portion of Alberta, grasses are the predominant vegetation, though more colourful flowering plants such as purple clover are also abundant. Shrubs such as rose and willow grow along river or streambanks. Large mammals include pronghorns and white-tailed deer, while smaller animals such as the ground squirrel, mouse, bat and vole are common. Prairie falcons, meadowlarks and sharp-tailed grouse share the area with many other bird species. In addition to birds and mammals, other inhabitants include reptiles, amphibians and insects. Examples include garter snakes, toads, and grasshoppers.

Aspen parkland - This ecosystem covers almost one tenth of the province. Aspen groves alternate with grasslands and in some areas, aspen and willow are interspersed with conifers. Other plants include fescue grasses, sedges, prairie roses and the crocus or anemone. Coyotes, hare, deer and lynx can be found in parkland areas. Chickadees, woodpeckers and other birds frequent the trees while the ruffed grouse nests on the forest floor.

Boreal forest - This zone covers more than half the province. It is highly variable with areas of mixed poplar and white spruce, black spruce muskeg, and patches of spruce, pine, larch, birch and jackpine. Other plants in the area include saskatoon, strawberry, horsetails, and a variety of mosses.

NATURAL ECOSYSTEMS IN ALBERTA



Warblers and flycatchers thrive on the insect populations, while the call of the loon is often associated with lake areas. Muledeer, moose, flying squirrels and the timber wolf reside in the boreal forest, as do the wolverine and many smaller animal and insect species.

Mountains - Alberta's mountain region extends in a narrow band along the southern half of the boundary with British Columbia. Again, variable terrain leads to a wide variety of species. Slope is an important factor, since it affects the development of soils and the amount of moisture retained. Where soil and moisture are suitable, coniferous forests have developed. On dry alpine meadows, a profusion of low-growing flowering plants provides a colourful summer carpet. Some steep slopes grow little more than lichen, but somehow the Rocky Mountain goats manage to survive on the bare slopes of higher elevations. Bighorn sheep, bears, elk and marmots inhabit less severe portions of the area. Most insects, because they are cold-blooded, require warm temperatures before they exhibit much activity. However, some insects such as the ice worm and the snow flea or springtail are active on snowy surfaces early in the spring.

Aquatic - We definitely **don't** want to see living organisms in the water we drink, but water in nature is different. Water provides a home for many species of aquatic plants, animals, invertebrates, and microorganisms. Its shorelines also lend variety to other ecosystems as they cut through prairie, mountain and forest to provide shoreline or riparian habitat. The oxygen levels in bodies of water are critical to the survival of the aquatic organisms present. The growth of plant life such as duckweed, algae, cattails, and water lilies depends on the depth of the water. Fish of course are aquatic, but muskrat, beaver, otters and many shore birds require riparian habitat. Other aquatic organisms include snails, fairy shrimp, and the larvae of many insects such as mosquitoes and dragonflies.

PLANT CLASSIFICATION AND GROWTH

According to Kermit the Frog, "It's not that easy being green." Not many animals other than insects share Kermit's colour, but most higher plants do. A tree that is turning yellow or brown in summer is not healthy. Yet that is precisely what is happening in areas of the world where acid rain is a problem. Such changes in plant life give one of the most obvious indications that environmental problems exist. The survival of green plants is critical to the survival of the planet.

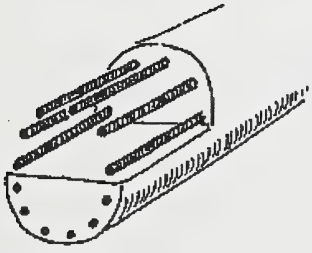
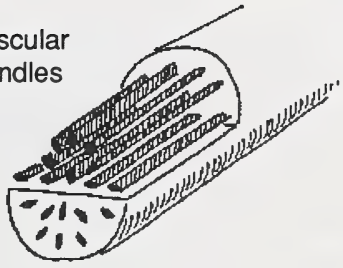
All forms of animal life depend on green plants for food, whether directly or indirectly through the food chain. Higher plants - those that contain the green pigment chlorophyll - can utilize the energy from the sun to transform carbon dioxide and water into the carbohydrates on which other organisms depend for food. In doing so, they also release oxygen into the air. Thus while respiration in both plants and animals requires oxygen and gives off carbon dioxide as a waste gas, in light conditions plants photosynthesize, using the CO_2 and restoring oxygen to the air.

$$\underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O} \longrightarrow \underset{\text{carbohydrate}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2}$$

Although green plants include mosses and ferns, the plants we encounter most frequently can usually be placed in one of two categories - Gymnosperms or cone-bearing plants (that's right - Christmas trees. Well, **most** of them are evergreen and resemble Christmas trees!) and the Angiosperms or flowering seed plants. These include grasses and some species with fairly inconspicuous flowers as well as plants with brightly coloured flowers.

These two groups are part of a larger classification known as the vascular or vessel-containing plants. Just as we have blood vessels, plants have tubular vessels or vascular bundles which allow the movement or translocation of fluids throughout the plant. In addition to water and nutrients, these may carry other compounds including plant hormones (yes, just like you, plants have hormones too!) The arrangement of these vascular bundles within a stem is just one of the features used to distinguish monocotyledenous plants such as grasses and lilies from dicotyledenous plants such as dandelion, rose or aspen (see chart below). Though this chart offers a guideline, exceptions occur and except for the number of seed leaves, a single feature is not reliable in classification. Seeds of monocots

COMPARISON OF CHARACTERISTICS BETWEEN DICOTS AND MONOCOTS

DICOTS		MONOCOTS
	cotyledons	
net-veined 	leaves	 parallel-veined
	vascular bundles	
in 5's or 4's as in seed chambers 	flowering parts	 in 3's
in 5's or 4's or multiples 	seed chambers in fruit	 in 3's or 6's

have a single seed leaf or cotyledon while dicot seeds have two cotyledons. Because monocots usually have long narrow leaves, dicots are sometimes referred to as broad-leaved species even though not all of them have broad leaves.

Growth occurs differently in these different groups of plants. Therefore, plants may also respond differently to different conditions or different compounds. For example, some herbicides will kill broad-leaved plants at concentrations which do not harm grasses.

If you could put a permanent mark on a tree trunk at the one meter level and the tree grew 20 cm. in height per year, where would the mark be in 5 years? At the two meter level? Sorry - no! It would still be at the one meter level. Tree trunks grow from the top, not the bottom. Roots grow in the opposite direction, but the principal is the same - lengthwise growth only occurs at the tip. Branching occurs from lateral buds which are formed during growth. Again, growth occurs only at the branch tip. A girdle scar is left where new growth begins each year (see diagram).

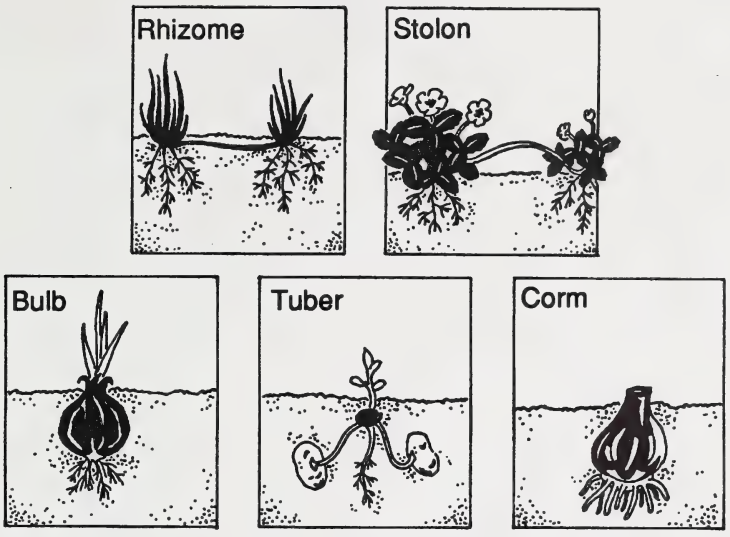
In plants, growth occurs in a specialized tissue known as a meristem. Apical root and apical stem meristems cause longitudinal growth of roots and stems. This is known as primary growth. In woody species, tissues also develop in other meristematic regions - the cork cambium on the outside to produce bark and the vascular cambium to produce new transport vessels. This secondary growth allows plants to grow in width as well as in height. Herbaceous plants such as the buttercup have no secondary growth, while semi-herbaceous plants such as the sunflower have a limited amount. In many grass species, the growing section remains at the base and leaves grow up from it. Therefore, when you cut the grass, it just grows back because you haven't damaged the growing point.

Like animals, plants have compounds known as hormones which help to regulate cellular activity. Auxins are one of the best-known groups of plant growth regulators or phytohormones. Indoleacetic acid (IAA) is the only naturally-occurring auxin. Very low concentrations of these compounds can stimulate plant growth. However, too high a concentration will lead to plant death. Auxins may be inactivated by light and by enzymatic action so toxic accumulations do not occur under natural conditions. Auxins can be

translocated up and down within the plant. Broad-leaved plants are sensitive to lower concentrations of auxins than are grasses. Auxin analogs can therefore be used as selective herbicides, since rates sufficient to kill broad-leaved weeds would not harm a cereal crop (a grass type of plant). Other types of phytohormones include compounds known as cytokinins which promote bud formation and kinins such as gibberellic acid which promote stem elongation.

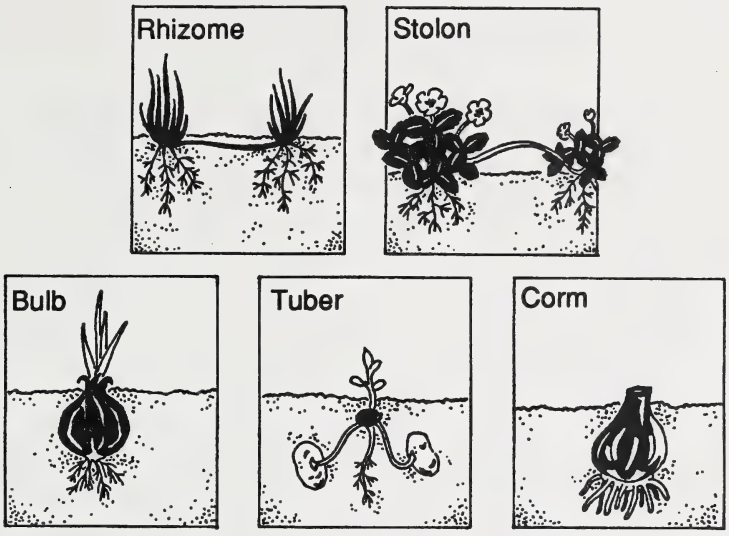
Seed production is a valued characteristic in some plant species. The carbohydrate stored in a seed is important not only to the survival of the plant species but also to many other organisms which use it for food. Grains, corn, peas and beans are staples in most human diets. However, not all seeds are desirable. A single plant of the weed species hedge mustard can produce over half a million seeds in one year! Not all seeds have the same requirements for germination either. Some can germinate as soon as they are ripe, but many, particularly those that have adapted to cold climates, are dormant and require a cold spell to break that dormancy and allow germination. This prevents fall germination when seedlings would be killed by frost. Other seeds may require specific conditions or microbial action (activity by bacteria) to overcome dormancy. For example, the jackpine requires extreme heat before its seeds germinate - an adaptation which helps it renew forest areas following fire.

While seeds are the most obvious method of reproduction in plants, there are other methods as well. Have you ever rooted a cutting of ivy or an African violet leaf? Reproduction by methods other than seeds is known as vegetative reproduction and results in new plants which are genetically identical to the parent plant. This cloning, the production of new plants from older parent tissue, can also occur naturally. In quack grass, aspen and many other species, new plants can grow up from specialized underground stems known as rhizomes. In aspen , these clones can cover large areas up to several hectares. Plants such as strawberries have stolons. These are similar to rhizomes but are above the ground. Plants may also have specialized root structures such as corms (e.g. gladiolus), bulbs (e.g. onion, tulip) or tubers (e.g. potato).



While growth of new plants from rhizomes is important in propagation, regrowth from old roots is another survival adaptation. When winter kills the tops of plants, roots of some species can survive to grow again the following spring. These perennials have an early start in spring when moisture conditions are good and compete well against annuals which must start from seed each spring. Annuals are more vulnerable to damage in spring because they don't have the extensive root systems and depth of the perennials, which are therefore better able to withstand dry conditions or a late frost. Perennial roots may be very deep. Roots of the perennial sow thistle can be 3 metres deep while field bindweed may extend 6 metres into the soil.

Knowledge of the plant growth factors which affect the species in an area is important in planning a vegetation management program. Mowing an area with extensive rhizomes below the surface will not prevent regrowth. Neither will the use of a herbicide which is not translocated to the roots. Whether you are planning dandelion control in a lawn or golf course, weed control in a canola crop or protection of seedlings in a reforestation project, you need to understand the problem if you are to find an effective solution.



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INTRODUCTION TO VEGETATION MANAGEMENT

Competition. Business in our western economic system is based on it. We all admire the medal-winning athlete who runs, swims, skates or skis the fastest or best. Scholarships are awarded to those who excel in academic competition. Since the time of Charles Darwin, scientists have accepted that natural survival of an individual or a species is also based on competition. Individuals thrive when they have a competitive advantage over others. This advantage in the animal world may be keen eyesight or the ability to move quickly. In the plant world, it may be the plant that produces seed quickly in the north where the growing season is short or the plant that can survive a drought on the prairies. A plant with a hardy overwintering root system or which produces seed quickly will survive in the north while those with shallow root systems requiring a long growing season (150 frost-free days) to produce seed just won't make it!

Unfortunately, the plants that compete well naturally aren't always the plants most prized for human purposes. Weeds such as bindweed and sow thistle may compete well in a farmer's field but you can't make flour from them. Trees obscuring vision along a roadside threaten human safety while trees near a power transmission line could start a forest fire. Workers on a reforestation project may plant out large numbers of seedlings, but if they are choked out by other plants, very few will make it to maturity.

In such instances, most people choose to use some form of plant growth control. For the farmer, cultivation practices have some effect on the presence of unwanted or "weed" species. Mowing can be effective in controlling roadside plant height. Cutting of trees along powerline rights-of-way limits vegetative growth. In most cases, these techniques are combined with some herbicide use - the application of chemicals which control plant growth.

Weed Control

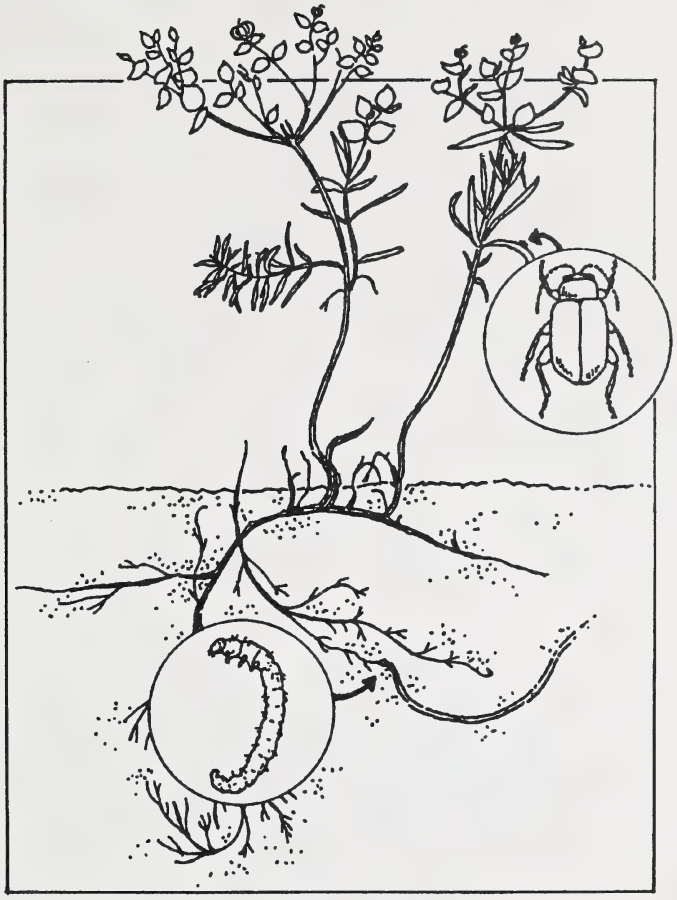
For farmers and homeowners, the goal of vegetation management is to optimize growing conditions for desired species while reducing or eliminating undesired or "weed" species. Homeowners may choose to pull, cut or hoe weeds or they may choose a chemical form of weed control. Chemical

forms include herbicide alone, herbicide in a weed bar, or herbicide mixed with fertilizer. Homeowners choosing to use chemical control for broadleaf weeds (dicots) commonly use 2,4-D. Other chemicals may be used for some specific weed problems. An increasing number of homeowners are choosing to avoid the use of chemicals and are relying on mechanical means to keep weeds under control in their lawns and gardens.

Farmers have much larger areas to control and therefore hoeing, pulling, etc. are not options. Still there are some cultural methods which can be used to control weeds. Summerfallow fields can be ploughed to break up the roots of perennial weeds. However, this extra cultivation leaves no ground cover and may lead to soil erosion. Some perennial crops such as forages compete well against weeds. Crops such as fall rye and winter wheat which germinate in fall, then require a cold spell for further growth, get a headstart in spring so can compete well against some weed species. However, they are not suitable in most areas of Alberta since winters in the north are too severe.

One biological control method which must be carefully evaluated for environmental implications is the use of insects which have a specific appetite for particular weeds. Several beetles have become established which feed on the roots of leafy spurge. A beetle species and a weevil which help control toadflax are also now widespread in Alberta. Such control methods are very effective, since once established, the control species are self-perpetuating.

Research is ongoing in the search for microbial herbicides. These are strains of bacteria or fungi which will attack weed species and cause them to become diseased. Such herbicides would be very specific for the weed



Leafy Spurge with flea beetle predator
(larvae feed on roots, adults feed on leaves)

species and therefore would cause no environmental damage since they do not affect non-target species.

In southern Alberta, sheep are used in some areas to help control leafy spurge, since they seem to preferentially graze that species. Repeated grazing will eventually starve the root's underground storage systems and prevent regrowth. However, this control method is obviously not practical for a grain field or canola crop!

For now, most farmers continue to use herbicides to control weeds, though integration of various control techniques should in the future play an increasingly large role in vegetation management.

VEGETATION MANAGEMENT (RIGHTS-OF-WAY)

Have you ever driven through a forested area with wide clearances on each side of the roadway? Maybe you've even thought what a neat feeling it would be if the trees grew right to the roadside. But think again. What if lightning struck a roadside tree and it fell in front of you as you were travelling 90 km/hr? Worse yet, what if it fell on your car? What if you approached a corner and the driver had to ease out into the intersection to see around the trees? What if a deer suddenly appeared in front on you? Risky? You bet! Not only that, but in winter, a narrow right of way (ROW) could act to catch snow and snow removal would be extremely difficult if trees crowded the roadside. To maintain public safety, roadside rights-of-way are kept clear of vegetation which might obscure vision or interfere in any way with traffic flow.

The same considerations apply to railway ROW's. Above pipelines, even though they are buried, ROW's are maintained because access is important. The cleared areas make regular checks easier so that problems can be spotted quickly and rectified before any serious environmental damage is done. Access is also important on powerline ROW's.

Picture a forest clearing - warm sun beating down on a grassy expanse dotted with colourful wildflowers; possibly a deer browsing near the forest

edge, a ground squirrel's high-pitched alarm disturbing the stillness as a hawk soars overhead. What shape is your clearing - more or less round? Square? Rectangular? What if your clearing were only 20 metres wide but extended for thousands of kilometres? What if you **had** to keep it clear of trees? That is precisely the problem facing power companies in this province. In all, there are more than 155,000 km of powerline rights-of-way throughout Alberta and their ROW's must be kept clear of trees.

Most Albertans take electricity for granted. The majority of homes use electricity for light, cooking, laundry and even entertainment with radio, T.V. and VCR's. Most furnaces require electricity to function properly so that a disruption in electrical supply, while an inconvenience to homes in summer, may be dangerous in winter. For users such as hospitals, a disruption is dangerous at any time.

To protect electrical transmission lines from damage, to ensure that access is not impeded if a problem does arise, and to avoid the possibility of forest fires starting from trees falling on the lines, it is essential that trees be kept at a safe distance from overhead lines and that the ground below the lines be safe for vehicular access (e.g. no stumps hidden in tall grass).

In many areas, particularly on the prairie and in agricultural areas, power lines often share road rights-of-way and even if they don't, the land is relatively level and tree-free so access can be fairly easily maintained. In more remote areas, particularly in the northern part of the province, maintaining access while minimizing environmental impact has presented a challenge. The maximum tree-free width depends on the average tree height in an area. Where trees grow to a maximum of 10 metres, then at least 20 metres must be kept clear of trees.

The environmental disturbance caused by the initial clearing of a ROW is inevitable. However, once construction is complete, regrowth of some types of vegetation is encouraged. Once a line has been built, ground cover needs to be established quickly to prevent soil erosion. Alsike clover and grasses may be planted initially until native species can grow up to establish a more natural vegetative community. The area must be kept clear of trees, but shrubs such as dogwood or willow are acceptable as long as the stands are not too thick.

Although the initial clearing and construction of transmission and pipeline ROW's may scare wildlife away from the area, an established ground cover which includes herbaceous plants, grasses and shrubs may actually enhance wildlife habitat by providing areas of browse for deer and other large animals. The "Edge Effect" provides a more varied habitat which may also benefit smaller animals. For example, brush piles near the edge of cleared near areas can provide nesting habitat for some bird and rodent species.

Once a stable ground cover has become established, control of woody vegetation is the major concern. Along roadsides and other easily accessible areas, regular mowing is effective in controlling much of the growth. In wooded and more isolated areas, this is not a practical option. There control methods depend on the dominant woody species.

Where spruce stands are very thick, herbicides may be used but as long as stands of spruce or other conifers are not too thick, shearing young trees at ground level prevents regrowth. Seedling growth is not an urgent problem since young spruce and other conifers grow slowly, only 30 to 100 cm during the first ten years, depending on conditions. Although after that time they may grow as much as 50 cm/year, management crews usually travel the ROW every three to five years to ensure the young trees do not cause a problem.

In most ROW vegetation management programs, the greatest problems occur in areas where poplar trees predominate. Young poplars grow much more quickly than young conifers - from 30-60 cm/year. Mechanical removal is not effective enough since it promotes suckering of new plants from the roots. Therefore, some time after mowing or slashing operations, a systemic chemical treatment is required to kill the roots. To maximize control, chemical treatment should occur 2-3 years after cutting.

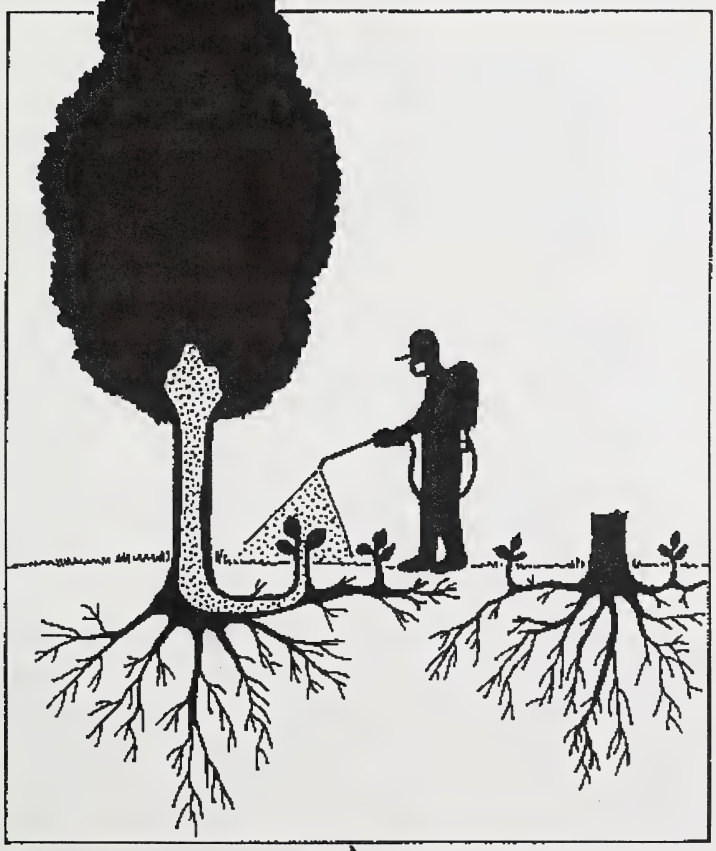
Once the ground cover has been established, lines are checked annually to ensure that trees are not encroaching on the right-of-way. Each line crew usually has a licensed applicator to supervise herbicide application. The most commonly used herbicides are 2,4-D, dicamba, and Garlon 4. Their auxin-like properties can control many broadleaf plants. Selectivity is achieved with careful application only to those plants that might cause a problem. A hand-held sprayer is used whenever possible so that only the plants which need to be controlled come in contact with the herbicide. Broadcast spraying is limited to thick stands where it is not possible to cut or to apply herbicide to every tree individually. This cautious approach to spraying ensures that herbicide use and environmental impact is kept to a minimum. No herbicide is used within 30 metres of a body of water (a requirement under the Agricultural Chemicals Act). This prevents contamination of the water supply.

On substation and yard sites, dried vegetation could pose a fire threat. Therefore, it is important to keep the ground clear of noxious weeds as well as suckering species such as poplar and raspberry. Often the site is gravelled and no vegetative ground cover is necessary. On these limited areas, long-term residual herbicides may be used in combination with short-term or non-residual compounds. The product should be selected to suit the plants and the soil type present, since products need to be restricted to the site. Barrier cloths are being used at some sites to prevent the establishments of perennial plants.

HERBICIDE USE

Cutting off an army's food supply is one way to win a war. That is precisely why herbicide research was conducted during World War II. The product developed at that time was 2,4-D which was released for public use in 1947. Since that time, many other herbicides have been developed , some for very specific uses and some for more general vegetation management, but 2,4-D still maintains a substantial share of the herbicide market.

Vegetation management attempts to limit or control the growth of some plants while encouraging others. For most large-scale purposes, herbicides form part of an integrated program which combines other techniques such as mechanical methods and species selection. Most herbicides are selective and are used to control only certain types of plants. Control of all plant growth is required only in occasional instances.



In selecting herbicides for particular uses, it is important that applicators know the mode of action, since differences in action and translocation affect the suitability of a herbicide for a particular task. For example, in controlling woody plants, particularly aspen which spreads by root suckering, translocation to or uptake by the roots and activity within the root will be important in preventing regrowth following herbicide treatment.

Because herbicides are used for a variety of situations, a number of different compounds and formulations are available. Auxin analogs such as 2,4-D were the first to be used on a large scale. They can be translocated through the plant and accumulate in the meristem tissue where they can, at appropriate concentrations, cause uncontrolled growth and eventual death of the plant. They can be used selectively since broad-leaved plants including some woody species are affected at lower concentrations than grasses. Herbicides which affect other aspects of plant metabolism e.g. photosynthesis or amino acid metabolism are less selective.

Some herbicides bind tightly to soil particles so cannot be absorbed by the plant after initial application and cannot move with the ground water or leach through the soil. Leaching also depends on the formulation used, since some formulations are insoluble in water and so not subject to leaching. Most herbicides are subject to microbial degradation. This microbial activity depends on soil type, moisture, temperature and soil pH. Some photodegradation (degradation by light) also occurs.

Herbicides are variable in their effects on other organisms. One measure of toxicity is the LD_{50}. This is the dose at which 50% of a test population dies. Since this cannot be calculated directly for humans, a test mammal such as the rat is used. Generally herbicides have a low mammalian toxicity. Characteristics of a few of the active ingredients in herbicides registered for use in Canada are listed below.

2,4-D - One of the most widely-used herbicides, this auxin analog can be used to control aquatic vegetation, woody plants, and broadleaf weeds. It is primarily absorbed by the foliage but there is some root uptake. It is broken down by microbial activity and also by tolerant plants. It lasts less than six months in the soil. It may leach in coarse-textured soils. Some formulations are toxic to fish. Many formulations are available for home use e.g. weed bars for lawns. Both soluble and insoluble formulations are available.

Dicamba - Although not an auxin, Dicamba mimics the activity of natural plant growth regulators by increasing plant metabolic and growth rates and is used for purposes similar to the auxins. It is absorbed by roots and foliage, then translocated. Dicamba residues can persist for a year or more and can leach through the soils since it is not bound strongly to soil par-

ticles. Dicamba is included with 2, 4-D and many formulations available for home use.

Garlon 4 - After absorption through roots and foliage, this auxin-type herbicide causes an accelerated growth rate leading to death.It is used to control woody plants and broad-leaf weeds in non-cropland areas. It persists in the soil for up to a year and may leach in coarse soils. Garlon is only available for industrial use.

Glyphosate - This chemical inhibits amino acid biosynthesis and is used to control a wide range of annual and perennial grasses, broadleaf weeds and woody plants. It binds tightly to soil particles so there is little leaching. It is subject to microbial degradation but can persist for more than two months. It is moderately toxic to fish. Glyphosphate is available for use around the home where **no** vegetation is desired e.g., sidewalk cracks.

Mecoprop - This is a selective growth-regulating herbicide for weed control in lawns and cereal crops. It is usually mixed with 2,4-D and/or herbicides. It is particularly effective in controlling chick weed and clovers.

Paraquat - This non-selective herbicide kills plants on contact by breaking down cell membranes and inhibiting photosynthesis. It is water soluble but binds tightly to soil particles so becomes unavailable even though it persists in the soil. It gives a quick top-kill and may be used in combination with herbicides that give residual activity. Extreme care must be taken by the applicator to avoid skin contact or inhalation since it can cause respiratory failure and there is no known antidote.

Picloram - This auxin analog can persist for five years or more. It leaches in soils with low organic and/or clay content. Picloram is only available for agricultural or industrial use. It very active even at low concentrations.

Dicamba, 2,4-D and MCPA are used for weed control in agricultural crops and also in forestry and ROW management programs. Picloram is more toxic to plants and also more persistent than 2,4-D or MCPA and is used for broad-leaf weed and brush control on some roadsides and ROW's. Garlon 4 is a relatively new product and is being used increasingly in brush control.

Control of Herbicide Use - Like other pesticides, herbicides must be registered under the federal Pest Control Products Act before they can be sold in Canada. The provincial Agricultural Chemicals Act provides regulations for sale and use in Alberta. It also requires safe disposal of containers so that they are not allowed to contaminate water sources. Training programs are available and commercial applicators must be licensed by the provincial government. Where herbicides are to be used on private land, owner permission is required. A permit is required before herbicides can be applied to public or crown lands and these permit applications are reviewed by several government departments.

Some weeds **must** be controlled. In Alberta, the Weed Control Act lists 50 weeds of which five are designated as restricted. Just allowing these restricted weeds to exist on your property is an offence. Fortunately these weeds are rare in Alberta and we hope to keep it that way! Dandelion and chickweed (which are definitely not rare!) are designated as nuisance weeds. Inspectors may require control of noxious weeds such as spurge and toadflax.

GLOSSARY

ANNUAL - a plant that completes its life cycle in a single season

APICAL DOMINANCE - inhibition of lateral bud growth by the apical bud of a shoot; believed to be a response to auxins produced by the apical bud.

AUXIN - a plant hormone which stimulates plant growth

AUXIN ANALOG - a chemical which, because of some similarities in molecular structure, has an auxin-like activity

AVENA - oat genus

AXIL - the upper angle where a leaf or twig comes off the main axis of the stem

BROAD-LEAF PLANTS - plants susceptible to control by auxin herbicides, usually with net-veined leaves

CARBOHYDRATE - products of photosynthesis; sugars, starches, cellulose

COLEOPTILE - the tissue surrounding the shoot of plants such as oats

CONIFEROUS PLANTS - plants which bear their seeds in cones

2,4-dichlorophenoxyacetic acid (2,4-D) - an auxin analog used as a herbicide

DORMANT - in a resting condition; alive but with relatively inactive metabolism and no growth

DECIDUOUS PLANTS - plants which produce leaves that fall regularly each year

DICOTYLEDONOUS PLANTS- flowering plants whose seeds contain two seed-leaves which act as storage for the endosperm

ECOLOGY - the science which studies the interrelationships between living organisms and between these organisms and their physical environment e.g. climate, terrain

ECOSYSTEM - a community of organisms and the environment in which they live

EDGE EFFECT - the influence of adjacent plant communities on the number of animal species present in the direct vicinity

ENDOSPERM - nutritive tissue of a seed

GIRDLE SCAR - scar formed around a stem or twig at the point between successive years' growth

HERBICIDE - a chemical used to kill plants

INDOLEACETIC ACID (IAA) - a naturally-occurring auxin

LATERAL BUD - a branch or flower bud produced in the axil of a leaf

LEAF SCAR - scar left on a twig following the fall of a leaf

LD_{50} - the dose of a chemical at which 50% of a test population dies

LEACH - to move through the soil with the ground water

MERISTEM - plant tissue where cell division and growth occur

METABOLISM - the chemical processes occurring within an organism

METABOLITE - any chemical that is part of a metabolic reaction

MIXED-WOOD COMMUNITY - a community in which two or more species are co-dominant

MONOCOTYLEDENOUS - flowering plants such as grasses which have a single seed leaf; this leaf does not store the endosperm

PERENNIAL - plant that continues growth from one season to the next; herbaceous perennials die back each year with only underground structures surviving; woody perennials have permanent woody stems above ground from which growth begins again in spring

PHOTOSYNTHESIS - process in green plants whereby energy from the sun is used to convert oxygen and water into carbohydrate

PHYTOHORMONE - chemical produced by a plant which helps to regulate plant growth and/or metabolism

RESIDUAL ACTIVITY - activity which remains for some time after initial application

RHIZOME - underground stem bearing buds in axils of reduced scale-like leaves e.g.quack grass

SELECTIVE HERBICIDE - one which kills only a certain type of plant

STOLON - a horizontally-growing stem that can root at its nodes or joints e.g., a strawberry runner

SUCKERING - growth of new plants from the roots of established plants

TERMINAL BUD - bud at the end of a stem

TRANSLOCATION - transport of materials within a plant